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A study of certain biology and biotechnology concepts in secondary school and high school course books in terms of scientific competency

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Abstract

It is very essential that the teachers of science and biology transfer the biology and biotechnology concepts properly by using good programs and teaching strategies as well as the development of biology and biotechnology education programs and models for science teachers and students. In recent years despite the increase of the technological equipments; course books are still the most important source, used in all levels of education, enlightening what the students will learn during the education period, what the teachers will teach and what method will be used during this period. Within this context, scientific quality, language, visuals, diagrams and models, context, technical and physical qualities, used in course books, have necessary roles for the students to learn the concepts properly and relate them to each other. The aim of this research is to study the distribution and relation of the subjects and the concepts of cell, chromosome, DNA, gene, GMO in Secondary School Science and Technology course books and High School Biology course books together with the scientific competency and accuracy level while defining these concepts. In this study, document method from qualitative analysis methods has been used. According to the results of the analysis, it has been identified that there are inadequacies of teaching the mentioned concepts present in the studied course books and relating them in terms of scientific competency and accuracy.

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Keywords: Biotechnology, Course Book, Certain Biology Concepts, Certain Biotechnology Concepts.

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1. Introduction

Modern biotechnology covering numerous areas such as medicine, pharmacy, food industry, agriculture and biology is of increasing interest in Turkey as well as elsewhere in the world. New biotechnological advancements are followed and carried out in new research at universities and institutes in Turkey not withstanding that the basic problem is encountered amongst the technical staff. Historically, biological sciences showed the most important developments after 1940's, such as the discovery of the lifesaving antibiotics and green revolution by using pesticide and putting chemical compounds into soil (Doelle, 2001). Especially many unknowns in molecular biology area began to be known with the finding of molecular shape of DNA by Watson and Crick. These developments in molecular biology and DNA rapidly gave a way to many inventions, discoveries and applications, one of which later was called biotechnology (Türkmen & Darçın, 2007). Biotechnology is a great area for students to understand the heredity, agriculture and critically evaluate the benefits and risks of this new technology. Promoting scientific literacy among all learners is a central goal of science education. Person who is scientifically literate on biotechnology can compare the processes of selective breeding and transgenic manipulation of plants, discuss the arguments for and against genetic modification of foods, describe the possible future impact of genetically modified foods, analyse public opinion about the use and safety of genetically modified foods (Dawson & Schibeci, 2003).

Teachers are important role to help their students become a scientifically literate. Teachers' knowledge on certain biology and biotechnology concepts especially GM foods and GM medicines risks and benefits of these technologies associated with their use is important. Teachers should know how to teach biotechnology effectively in order to help students understand the subject and create an effective learning environment. A teacher cannot be expected to teach what he/she does not understand. Therefore, educational programs should focus on improving science teachers' conceptions of the new technological development like as biotechnology with the anticipation that their own students' knowledge on the issue would improve (Hurd, 1998). The lesson plans on certain biology and biotechnology concepts should focus on students' understanding on ethical issues especially the concepts of cell, chromosome, DNA, gene, GMO, identification of GM foods in their diet, comparison of traditional methods of plant breeding and modern techniques of genetic engineering, identification of advantages and disadvantages to GM foods, and importance of responsible use of technology.

The development of biotechnology education programs and models for science teachers and students is of importance since the concepts of biotechnology are of significance to all science and biology teachers using good curriculums and instructional strategies (Dunham, Wells & White, 2002). It is important to know how people and students perceive and understand biotechnology and what are the misconceptions related to biotechnology. In this point, biotechnology education gains importance because the wrong information about biotechnology and negative attitudes toward biotechnology could only be changed through science and science education (Harms, 2002).

The aim of the studies on the biology education to reveal the causes of failures. The most important of reasons, most students' understanding of the concepts wrong in biology. In this situation, students' understanding of both the available information and makes it difficult to advance their knowledge further. In recent years, advances in genetics, draws attention to the importance of this science. In some countries, new methods and techniques have focused on putting out to provide better learning studies students of such as gene, DNA and chromosome concepts. However, few studies of this type in our country. Therefore, such as gene, DNA and chromosome concepts what students know and do not know, or how wrong they knew better than to learn these concepts should be investigated. Bahar, Johnstone & Hansell (1999) and Lewis & Wood-Robinson (2000) on the high school and college students and Tekkaya et al. (2000)'s high school graduates in their work, on the problematic issues related to cell division and genetics, and biology curriculum is inadequate understanding of the issues underlying this case has created difficulty for learning other subjects have suggested that. In this context, course books are the most important resource in the teaching and learning process. Because how the information presented in the course books, the language used in this presentation, pictures, diagrams and models, content, technical and physical characteristics have important roles in the development of students' thoughts. Quality of education takes place with high quality course books (Küçükahmet, 2001; Kikas, 2004; Kılıç, 2005; Atmaca, 2006; Laçin-Şimşek & Tezcan, 2008; Kırbaşlar & İnce, 2010; Karadaş, Yaşar & Kırbaşlar, 2012).

2. Purpose of the Study

The aim of this research is to study the distribution and relation of the subjects and the concepts of cell, chromosome, DNA, gene, GMO in Secondary School Science and Technology course books and High School Biology course books together with the scientific competency and accuracy level while defining these concepts.

3. Methods of the Study

This study was conducted according to the method of the document. Existing records and documents by examining the data collection "documentary screening" (Madge, 1965), "documentary observation" (Duverger, 1963), Rummel (1968) and many more researchers "document method" to describe as. Best (1959) this method if the existing records or documents, as the data source, refers to the systematic examination (Karasar, 2008).

This study consists of two parts: In the first part, one of 4^{th} and 5^{th} grade, two of 6^{th}, one of 7^{th} and two of 8^{th} "Science and Technology" course books and one of 9^{th}, 10^{th}, 11^{th} and two of 12^{th} "Biology" course books were coded in 2011-2012 terms and accepted as essential "Science and Technology" and "Biology" course book by Ministry of National Education. In the second part of the examination of course books is situated.

Examination of course books followed the steps:

1. Biology curricula specified in the course books and "cell, chromosome, DNA, genes, genetic issues and concepts" in this curriculum have been identified.
2. The identified issues examined in terms of concept carefully, the accuracy of concepts, relationships and handled by the format of the class curriculum was evaluated.
3. Missing or incorrectly concepts defined, suggestions were made to rectify this.
4. Literature search was carried out for the detected deficiencies and mistakes can cause a false learning or misconception and the findings of various researchers are included.

3.1. Samples

The sample of this study is formed by, in the academic year 2011-2012, one of 4^{th} (Agalday, Akçam, İpek & Kablan, 2011), one of 5^{th} (Bağcı et al., 2011), two of 6^{th} (6A: Comission, 2011a; 6B: Korkmaz, Tatar, Kıray & Kibar, 2011), one of 7^{th} (Tunç et al., 2011a) and two of 8^{th} (8A: Tunç et al., 2011b; 8B: Gündoğdu, 2011) classes taught in "Science and Technology" course books and one of 9^{th} (Ercan-Akkaya, Albayrak, Öztürk & Cavak, 2011a), one of 10^{th} (Ercan-Akkaya et al., 2011b), one of 11^{th} (Sağdıç, Bulut, & Korkmaz, 2011) and two of 12^{th} (12A: Comission, 2011b, 12B: Kıvanç & Yel, 2011) classes taught in "Biology" course books.

3.2. Analyzıng Data

Analysis of the research was designed for distributions and relationships in class curriculum between the genetic concepts and subjects such as cell, chromosome, DNA, gene, GMO in "Science and Technology" and "Biology" course books.

4. Findings

In accordance with the analysis made in the books of Science and Technology and Biology of the biggest scientific deficiencies in DNA and gene expression was found to be. The inadequacy of the definitions and that of the sampling images are pointed out in explaining the position and the function of the gene and DNA (Table 1).

Table 1. Gene Definitions in Science and Technology and Biology Course Books.

Class-Book	Page	Unit	Definition
8A-Science and Technology	37	Cell Division and Inheritance	DNA is the cell's authoritative molecule, and directs vitality actions such as, nutrition, respiration and reproduction. There are gene zones in DNA's structure that affects our genetic heritage specialities. Genetic heritage is carried on by genes.
8A- Science and Technology	40	Cell Division and Inheritance	Chromosomes carry DNAs, DNAs carry genetic heritage genes. Genes are made up of nucleotides.
8B- Science and Technology	17	Cell Division and Inheritance	Gene is located in chromosome structure and part of DNA which allows the transfer a specific feature for future generations.
8B- Science and Technology	37	Cell Division and Inheritance	DNA is composed of genes. Genes are composed of molecules called nucleotides.
9-Biology	102	Cell, Organism and Metabolism	Gene is a part of DNA, made up of nucleotides and responsible for at least one protein's or RNA's synthesis.
10- Biology	136	Cell Division and Reproduction	These DNA particles that are made up of approximately 1000-1500 base ranges make up our genomes.
11- Biology	114	Inheritance, Genetic Engineering and Biotechnology	Gene is called part of chromosome which allows the transfer of a inherited character to offspring. Gene, which is part of the DNA of about 1500 nucleotides.
12B- Biology	62	Inheritance	Genes are units which coding for protein synthesis and has information about the formation of inherited characters. Sequence and number of nucleotides in the gene that make each character different from the others.
12B- Biology	83	Inheritance	Gene is called the smallest parts of DNA strand that provides the formation of a character in organisms.
12B- Biology	129	Inheritance	Gene, a small part of the genome, is a unit of heredity passed from cell to cell and from insemination to fertilization. Gene in other words, the basic unit of heredity and a part of a DNA specific length with a knowledge of a protein molecule capable.

5. Results

According to the conclusion which is made by studying cell and genetic subjects in primary school Science and Technology course books and secondary school Biology course books: Cell structure is introduced to the students, for the first time in 6th grade Science and Technology course book. In this subject, cell is introduced, for the first time male and female reproduction cells and fertilization are explained, and the authorizing function of the core in the cell is mentioned as well as the fact that the core is the means by which genetic heritage is carried. About DNA and genes there is no information. Neither in 7th grade Science and Technology books. In 8A book, chromosomes-DNA-gene notions are defined and shown in images. But it cannot be understood clearly, with this definition and images, where genes are place in chromosome and DNA exactly. In 8A book, "Let's research and prepare" activity, genetic engineering and biotechnology notions and GMO notion, is explained in this activity; However whether students will learn these notions or not depends on the fact whether the teacher does this activity in the class or not. According to Tarhan, Cavas & Asan (2002), 8th grade Science and Technology course book has a structure that prevents the students do the activity with the necessary consciousness due to the fact that activities have priority over basic knowledge, and due to the lack of adequate questions which will direct students to the target knowledge. Temelli (2006) has pointed out most students in secondary school have difficulties in understanding notions and subjects about genetics, and notion fallacies. One of the main reasons of these notion fallacies is the fact that most classes are teacher oriented. "Genetically Modified Organism" notion is mentioned, in all primary school Science and Technology course books and Secondary School Biology syllabus, only once in an activity in 8th grade Science and Technology in 8A book. It does not take place in the subject itself. If the teacher does not do the activity in the class, it seems the notion will remain there.

"GM products are generated to meet the needs of the growing human population and having more efficient sustenance" definition is placed in 8B course book. Producible of oversized tomatoes, cucumbers, hundreds of wheat from only one seed, criticized with their possible damages to human health and these products under discussion position. The square watermelon image below the "DNA and the Genetic Code" section is shown an example for genetically modified product, and this lead to a misconception. As seen in the Table 1, it is understood from gene definitions that, genes are inside DNAs in chromosomes, and they are the means by which genetic heritage is carried on and are made up of nucleotides. However, it is not understood clearly where gene is placed in DNA. A clear location is not singled out in the images either. In a research of Tarhan, Cavas & Asan (2002), in evaluation of genetics units in 8th grade Science and Technology subjects, it is concluded that, the structure of DNA nucleotide chain cannot be understood, the definition of nucleotide unit is not clear, and it is very hard to understand this notion. Also, in the research by Tarhan, Cavas & Asan (2002), genetic unit is evaluated in various books confirmed by Ministry of National Education. In all the books that were evaluated, the images do not support the knowledge given in the subjects, and are inadequate. It has been concluded that in these books nucleotide unit which is crucial in understanding DNA nucleotide chain structure is not clear and hard to understand. According to Özdemir (2005), it has to be emphasized that DNA's specifity stems not from its chemical components but from the fact that the sequence of four kinds of organic bases are different. In a research of Temelli (2006), he questioned smallness and magnitude relationship, only 63% of the sampling gave the right answer to this question. In the same research, to the question about the "structure of genes" only 41.3% of the sampling gave the answer that gene is a part of DNA. In the research of Şahin and Parim (2002), it is concluded that, the relation between gene and chromosome cannot be understood clearly, as 25% of the participants stated genes are bigger than chromosomes. In the same way, in researches Lewis, Leach & Wood-Robinson (2000), Tatar & Cansüngü Koray (2005), Öztaş & Öztaş (1997), most of the participants stated chromosomes are bigger than the core. According to Tatar and Cansüngü Koray (2005), the cause of the inability to make chromosome-DNA-gene sequence right might be the fact that these notions are not understood clearly. In a research made by Saka & Akdeniz (2004), pre-service science teachers have notion fallacies in various subjects of genetics. Among these fallacies, there are fallacies about chromosome-gene DNA notions, such as; DNA is a part of chromosome; chromosome is a part of DNA, chromosome and DNA are the same thing; DNA; chromosome and gene are parts different from each other.

In 8A Science and Technology course book, there is an image of a tobacco plant to which a firefly's genes are transmitted by using biotechnical technics. In this image, it is emphasized that the tobacco plant is sparkling; this image might make the student think that the image is a visual for all GM products. In 9^{th} and 10^{th} grade Biology books, "cell" is described in detailed manner, and even though chromosome-DNA-gene relationship is explained as a genetic heritage component in the core, it is still not explained where the genes are exactly placed inside chromosome in DNA. There is a genetic topic in 11^{th} grade Biology course book and the concept of GM organism is included in a large extend. Describing the "GM organisms or transgenic organism is an organisms whose genes are modified by genetic engineers" is the first real information about GM organisms is handled 11^{th} grade Biology course book. The importance of biotechnology, genetic engineering and effects of genetically modified organisms on human health are emphasized in continuation of the subject. There is not cell and genetic topic in 12A course book, 12B course book is generally addressing cell, gene, and genetic subjects. In this case, students of high schools who choose the course book 12A will graduate without learning genetic issues. As seen in Table 1; at 8^{th}, 9^{th}, 10^{th}, 12^{th} grades gene definitions are made many times. These definitions, as pointed out before, do not help the exact position of the genes to be defined, and there are no images to support this.

In 12B Biology course book, the subjects are genetic engineering and biotechnology subjects. The applications in industry, cultivation and applications on humans and animals are told in detail. Among all these subjects, GM organism notion is not mentioned. GM products are very controversial subject, and only information about GM organisms is in 11^{th} grade course books, it is obviously in inescapable for student who graduate without learning this issue from high schools will learn GM organisms mostly from media if the teachers do not teach this subject in 12^{th} grade. Since such a controversial and up to date subject is not included in course books, if the teacher does not teach the subject in the class either, it will be inevitable that the students learn about this notion from media, and graduate without learning this subject. What they learn from the media is controversial news depending on personal or institutional ideas with no validity.

As a result, when examined in the definition of the concepts mentioned in the course books, to relate concepts in teaching and scientific shortcomings in the adequacy and accuracy were determined. These deficiencies can lead to learning these concepts and advanced the wrong information becomes available as the basis misconceptions seem to be a high lifetime risk. In this context, the fact that the course books which are the basic for teaching science do not cover the notions sufficiently causes the students to learn these notions in the wrong way, or in an inadequate way. It has been concluded by various researchers, that the notions that have not been comprehended totally, but have been learnt roughly and wrongly may cause notion fallacies and course book based notion fallacies are encountered very often.

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